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ON THE TERM *VIPULATVA* FOUND IN THE *MAHĀBHĀRATA*

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Abstract

The *Mahābhārata*, one of the two major epics of ancient India, refers to the data for *C*, *d*, and *t* of each of the Svarbhānu, the Moon and the Sun where *C* is circumference (*pariṇāha*), *d* is diameter (*viṣkambha*), and nothing is clear about *t*. So far *t* has not been interpreted by any modern scholar. The terms used for *t* in the *Mahābhārata* are *vipulatā*, *vipulatva*, and *viṣkambha*, each of which means is largeness, extent, or width. This paper aims at igniting the process of interpreting *t*. It shows that *t* is rectilinear and cannot be interpreted in the manner in which the body of the Svarbhānu, the Moon or the Sun be proved to be cylinder or ellipsoid or spherical segment or oblate spheroid or disk. That *t* is a range of extent to *d* is, although reasonable and feasible, not fully acceptable as the ratio between *d* and *t* is not the same for the data given for *d* and *t* in the case of each of the Svarbhānu, the Moon and the Sun. *t* can be conjectured to have been prevalent till *x* where 500 BCE $\leq x \leq$ 500 CE. *x* may go even beyond 500 BCE.

Keywords: *Mahābhārata,* and *vipulatva*

I. INTRODUCTION

The *Mahābhārata* ("Great Bhārata" or "Great ‹Account of› Bharata ‹Dynasty›") is one of the two major epics of ancient India, the other being the *Rāmāyaṇa*. It is a poem, in Sanskrit, woven around the story of a conflict between two dynasties, the *Pāṇḍavas* and the *Kauravas*, of the same clan. It has influenced the thoughts, actions, and culture of the people of Indian subcontinent since its composition.

The *Bhīṣma Parva* is the sixth of its eighteen books (*parvas*, i.e., divisions). Some verses of the chapter (*adhyāya*) 12 of its *Bhūmiparva* ("‹Concise› section (*parva*) on the lands ‹and seas except the *Jambūdvīpa*›") contain the data referred to for the dimensions of the Svarbhānu, the Moon, and the Sun. Those dimensions include circumference *C*, diameter *d*, and extent (*vipulatva*) *t*. So far *t* has not been interpreted by any modern scholar.

Among those who have encountered in true mathematical sense with *t*, as far as the present author knows, are E. Washburn Hopkins, R. C. Gupta, R. N. Iyengar, and the present author. Hopkins met it while interpreting the values for π from those data [Hopkins, 1902, pp. 154-155] where π is a non-terminating and non-recurring fixed ratio of the circumference, *C*, of a circle to its diameter, *d*, and is equal to 3.14159 when approximated to 5 decimal places. Similar is the case with Gupta [1990, pp. 45-47]. While discussing internal consistency of eclipses and planetary positions in the *Mahābhārata* Iyengar met it [Iyengar, 2003, p. 85]. The present author met it while discussing on when, why, and from where 3 was inducted into the *Mahābhārata* as the value for π [Jadhav, 2018, pp. 18-38]. During the period from 1883 to 1896 Kisari Mohan Ganguli published the English translation of the *Mahābhārata*. He ignored *t* while translating those verses [Ganguli, 2003, *Bhūmiparva*, pp. 28-29].

The purpose of this paper is to ignite the process of interpreting *t*, which the present author proposed in his paper published in 2018 [Jadhav, 2018, p. 22].

II. METHOD

This research is based on qualitative research methods. Data have been collected from the text of the *Mahābhārata*. Therefore, all data collection is primary. The next step is to interpret the data and give them a new horizon so that they can be understood. The most important meaning of this research is to find something innovative to interpret *t*.

III. DISCUSSION AND RESULTS

1. Verses of the *Mahābhārata* containing *C*, *d*, and *t*

In the *Mahābhārata*, information on the dimensions of the *Svarbhānu*, the Moon, and the Sun is passed to the blind king Dhṛtarāṣṭra by his charioteer Sañjaya through the verses as given below.

1º *svarbhānoḥ kauravaśreṣṭha*
yāvadeva pramāṇataḥ।
parimaṇḍalo mahārāja
svarbhānuḥ śrūyate grahaḥ॥
yojanānāṃ sahastrāṇi
viṣkambho dvādaśāsya vai।
pariṇāhena ṣaṭtriṃśad
vipulatvena cānagha॥
ṣaṣṭimāhuḥ śatānyasya
budhāḥ paurāṇikāstathā।
[Pāṇḍeya, vv. 6.12.40-42 first hemistich, p. 2572]

"O 'superior among *Kauravas*' (*Kauravaśreṣṭha*, i.e., Dhṛtarāṣṭra)! ‹I (i.e., Sañjaya) let you know› as many as the dimensions (*pramāṇas*) of the *Svarbhānu* are. O 'Great King' (*Mahārāja*)! It is heard that the planet (*graha*) *Svarbhānu* is round on ‹its› periphery (*parimaṇḍala*) ‹in shape›. Its diameter (*viṣkambha*, *d*) is twelve thousand *yojanas*, and it is thirty six ‹thousand *yojanas*› in circumference

(*pariṇāha*, *C*). And O Sinless (*Anagha*)! Its extent (*vipulatā*, *t*) is said by the *paurāṇika* learned scholars (*budhā*) to be sixty hundred ‹*yojanas*›."

2º *candramāstu sahastrāṇi*
rājannekādaśa smṛtaḥ‖
viṣkambheṇa kuruśreṣṭha
trayastriṃśat tu maṇḍalam|
ekonaṣaṣṭiviṣkambhaṃ
śītaraśmermahātmanaḥ‖
[Pāṇḍeya, vv. 6.12.42 second hemistich-43, p. 2572]

"O Ruler (*Rājan*)! The Moon (*candramā*) is handed down by memory to be eleven thousand ‹*yojanas*› in diameter (*viṣkambha*, *d*). O superior (*śreṣṭha*) among *Kauravas*! Its ‹peripheral› circle (*maṇḍala*, *C*) happens to be thirty three ‹thousand *yojanas* when calculated›. O High-souled (i.e., lofty-mined, *Mahātman*)! The extent (*viṣkambha*, *t*) of the cold-rayed (*śītaraśmi*) ‹i.e., the Moon› is fifty nine ‹hundred *yojanas*›."

3º *sūryastvaṣṭau sahastrāṇi dve*
cānye kurunandana|
viṣkambheṇa tato rājan
maṇḍalaṃ triṃśatā samam‖
aṣṭapañcāśataṃ rājan
vipulatvena cānagha|
śrūyate paramodāraḥ
patago'sau vibhāvasuḥ‖
[Pāṇḍeya, vv. 6.12.44-45, p. 2572]

"O 'descendant of the Kuru ‹clan›' (*Kurunandana*)! The Sun is eight thousand ‹*yojanas*› and another two ‹thousand *yojanas*› in diameter (*viṣkambha*, *d*). O Ruler (*Rājan*)! From that its ‹peripheral› circle (*maṇḍala*, *C*) comes to be equal to thirty ‹thousand *yojanas*›. O Ruler (*Rājan*)! It is fifty eight hundred ‹*yojanas*› in extent (*vipulatva*, *t*). And O Sinless (*Anagha*)! This is what to be heard about the benevolent (*paramodāra*), fast-going (*patago'sau*) and resplendent (*vibhāvasu*) ‹Sun›."

2. Status of *t*

The data referred to for *C*, *d*, and *t* in 1º, 2º, and 3º have been assembled as shown in Table.

Table: The data referred to for *C*, *d*, and *t* in the *Mahābhārata*

Planet (*graha*)	Ganguli [2003, 6.12, pp. 28-29 and footnote no. 29.1]			In *yojanas*			π	
	In *yojanas*		π	*C*	*d*	*t*	Hopkins [1902, pp. 154-155] $(C+t)/d$	Gupta [1990, pp. 45-46] C/d
	C	*d*	C/d					
Svarbhānu	42000	12000	3.5	36000	12000	6000	3.5	3
Moon	38900	11000	$3.53\dot{6}\dot{3}$	33000	11000	5900	3.5+	3
Sun	35800	10000	3.58	30000	10000	5800	3.58	3

In order to calculate the value for π from each of 1º, 2º, and 3º Hopkins took *t* as the part of *C*. In mathematical terms, he holds that $(C + t) \rightarrow C$.

Ganguli, prior to Hopkins, in his translation offered for each of 1º, 2º, and 3º, refers to the value of *C* only, without any mention of *t* at all, as shown in Table,

which Iyengar does not consider to be justified [Iyengar, 2003, pp. 85]. For both of Ganguli and Hopkins,

$$\pi_{\text{Sun}} > \pi_{\text{Moon}} > \pi_{\text{Svarbhānu}}.$$

R. C. Gupta found the values inferred by Hopkins to be the yielding of his gross misinterpretations. Gupta corrected those misinterpretations and pointed out that the value implied in the data of each of those three cases for π is 3 [Gupta, 1990, pp. 45-47]. The same value was already interpreted by him from the data referred to for the Sun in his paper published in 1975 [Gupta, 1975, pp. 1-2].

In his translation of each of 1º, 2º, and 3º, Gupta refers to the values of *C* and *t* separately. "For the calculation of π, the thickness *t* is not needed whatever be its interpretation [Gupta, 1990, p. 46]." This is Gupta's argument. The present author endorses it for the following three reasons. (1) It allows us to hold that one must focus on the values of *C* and *d* when to determine the value for π. (2) It allows the datum offered in each case for *C* to remain intact. (3) It deduces that

$$\pi_{\text{Sun}} = \pi_{\text{Moon}} = \pi_{\text{Svarbhānu}},$$

which is expected [Jadhav, 2018, pp. 21-22].

Here we are able to see that nothing is clear about the status of *t*.

3. Efforts and Suggestions for Interpretation of *t*

3.1 The term occurred for *t* in 1º is *vipulatā* and in 3º is *vipulatva* while in 2º is *viṣkambha*. The meaning of *vipulatā* or *vipulatva* is largeness, extent, or width [Cappeller, 1891, p. 499]. The general meaning of *viṣkambha* is also width [Cappeller, 1891, p. 499]. And its particular meaning in ancient Indian mathematics is diameter. That is why Mahāvīra (c. 850 CE) defines the diameter of a circle as its middle most breadth [Rangacharya, 1912, v. 7.229½ second hemistich, p. 588].

The *Bhārata Darśana*, a non-literal Kannaḍa translation of the *Mahābhārata*, takes *t* to mean thickness, which R. N. Iyengar finds to be doubtful [Iyengar 2003, pp. 85 and 115]. The English term used for *t* by Hopkins is extent [Hopkins, 1902, p. 154]. The same term has been used by the present author for *t* in his translations offered for 1º, 2º, and 3º. In this regard, he followed Hopkins. Gupta took it to be thickness while translating those verses [Gupta, 1990, p. 46]. He seems to have arbitrarily done so.

On the basis of these meanings and translations it can be said for certain that *t* is a rectilinear dimension.

3.2 Now we would like to make efforts, using some suggestions, to see where *t* fits into. *C* and *d* out of *C*, *d*, and *t* are reasonable but *t*, which is not equal to *d* in each case, becomes undesirable when the Svarbhānu, the Moon, and the Sun are assumed to be in spherical shape. *t* becomes meaningful when the Sun is considered to be a luminous disc as seen from Earth, rather than a spherical source of light. The same perception may be applied on the Svarbhānu, and the Moon.

This perception leads us to assume that each of the three bodies is a cylinder of which circumference is *C*, diameter is *d*, and thickness is *t*. See Fig. 1. But we do not have any source which we can refer to to show that anyone of them has ever been considered a cylinder.

"Rāhu ‹i.e., Svarbhānu› is to be taken like a solid disk (like the one used in discus throw). The central section through

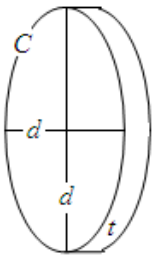

Fig. 1

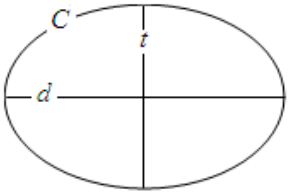

Fig. 2

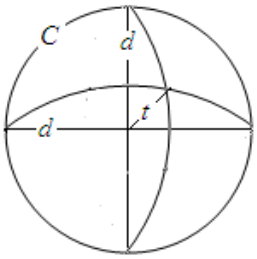

Fig. 3

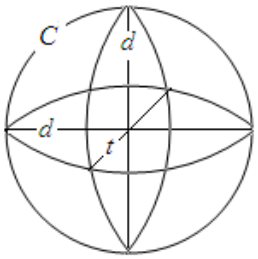

Fig. 4

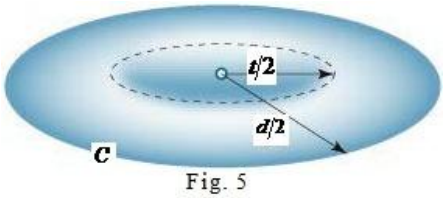

Fig. 5

the maximum thickness and a diameter of the peripheral circle, will be a symmetric closed curve which will resemble an elongated circle or an ellipse of axes *d* and *t* [Gupta 1990, p. 46]." This remark, as it is not accompanied with any diagram which could clarify our doubts, of Gupta makes the present author to visualize that each of the three celestial bodies is somewhat like Fig. 2 or Fig. 3 or Fig. 4 or Fig. 5.

As far as Fig. 2, the vertical middle cross-section of an ellipsoid, is concerned, the data provided in the *Mahābhārata* are not in accordance with either of the two later rules, namely $C = 2\left(d + \left(t/2\right)\right)$ [Rangacharya, 1912, v. 6.21 first hemistich, p. 112] and $C = 2\sqrt{d^2 + 6\left(t/2\right)^2}$ [Rangacharya, 1912, v. 6.63 first hemistich, p. 461], given by Mahāvīra (c. 850) in India for finding the perimeter, say *C*, of an ellipse in the *Gaṇita-sāra-saṅgraha* where *d* and *t* are its major and minor axes respectively.

Fig. 3 is the segment of a sphere; *C* and *d* are circumference and diameter of its circular section and *t* is its thickness. The *Sūrya Prajñapti* (c. 500 BCE) refers to the term 'umbrella-shaped' (*chattāgāra*, Skt. *chatrākāra*) for Fig. 3 [Madhukara, 1995, sūtra 19, p. 24 and sūtra 25, pp. 41-42; also see Datta, 1929, p. 143]. Later, we find the terms 'sacrificial fire-pit' (*catvāla*) and '‹the back of a› tortoise' (*kūrma*) referred to by Mahāvīra (c. 850 CE) for its concave (*nimna*) surface and convex (*unnata*) surface respectively. He also refers to the rule for finding its surface [Rangacharya, 1912, v. 6.25, p. 112]. Fig. 4 is obtained when two segments of the equal dimensions including thickness equal to $t/2$ are joined. In fact, Fig. 4 is an ellipsoid. Lengths of its principal axes are *d*, *d*, *t*. Since, for the given data, the first two axes (i.e., *d* and *d*) are equal and the third axis (i.e., *t*) is less than the first two equal axes, Fig. 4 is an oblate spheroid, which is a special case of the ellipsoid. Again we do not have any source to prove that Fig. 3 or Fig. 4 is a true suggestion.

Since *viṣkambha* (diameter) and *vipulatva* can replace each other, $t/2$ may be radius of a disk of which central radius is $d/2$ as shown in Fig. 5. The distance between the centres of $d/2$ and $t/2$ would have been offered as there is no fixed ratio between *d* and *t* for the given data if Fig. 5 had been a true suggestion.

One anonymous learned scholar suggests that *vipulatva* (*t*) may refer to, perhaps, variation in the imagined

diameter (*d*) or area, depending on the apparent distance in the sky as observed from Earth. What the present author understands on the basis of his suggestion regarding *t* is that *t* is a range of extent to *d*, in which *C* varies from πd to $\pi(d + t)$ when *d* varies from *d* to $(d + t)$. His suggestion appears to be reasonable as it does not prevent us to assume the Svarbhānu, the Moon, and the Sun in spherical shape. It would be fully acceptable if the ratio between the data given for *d* and *t* of each of the *Svarbhānu*, the Moon and the Sun were the same.

4. Conjectures on the Historicity of *t*

"It ‹i.e., the *Mahābhārata*› is," writes the present author, in his paper published in 2018, "of composite nature. And the *Bhūmiparva* is a later addition to it. … If consistency is preferred to as a sound criterion in determining when 3 as the value for π in the *Mahābhārata* was used, we can say that *x* is not only the date of incorporating 1º, 2º, and 3º in it but also the date of the use of 3 as the value for π in it ‹where 500 BCE $\leq x \leq$ 500 CE›. Both of the *Mahābhārata* and the *Purāṇas* underwent changes. The *Purāṇas* continued to be revised even after the *Mahābhārata* was finally recast until they were shaped into the present *Purāṇas* from their older form. Concept of *t* is not found in the present forms of the *Purāṇas*. It was borrowed from some older *Purāṇas* into the *Mahābhārata*. The dimensions referred to for the Rāhu ‹i.e., *Svarbhānu*›, the Moon, and the Sun also seem to be from those *Purāṇas*. Keeping all these in view … ‹it can be said› that *x* tends to 500 BCE in its range extending from 500 BCE to 500 CE. … *x* may go even beyond 500 BCE. It would not be reasonable if we say that one who has incorporated 1º, 2º, and 3º in the *Mahābhārata* was unaware of the better values available during or prior to *x* in India for π other than 3. In regard to the use of 3 as the value for π, his source of information was the *Purāṇas*, certainly their older form, which were the works for common public instruction. If simplicity, prevalence, and traditionalism are preferred to as a sound criterion to calculate *C* for a given *d*, no other option for π is better than 3. This is what was followed in the *Purāṇas*, whether they belong to the older form or to the present form, and because of them in the *Mahābhārata* [Jadhav, 2018, pp. 34-35]." "We attest," writes he prior to these findings, "the use of 3 in the present form of the *Purāṇas* but we do not find *t* to be mentioned in them. For this reason, one cannot be allowed to infer that 3 was brought into the *Mahābhārata* from the present *Purāṇas* and *t* got its entry from somewhere into the great epic. It would not be unreasonable if we infer that 3 was received into the *Mahābhārata* from the older *Purāṇas* wherein *t* may have been in use [Jadhav, 2018, p. 29]." On the basis of these excerpts we can say that *t* has a historical origin and developed through history. The following conjectures can be made here. Concept of *t* seems to have been prevalent till at most *x*. Since it is not reported to have been employed in any form in any Indian treatise on "mathematical astronomy" (*Siddhānta*) or mathematics (*Gaṇita*), it seems to have been later rejected, that too little after *x*. That is why it is not found in any of the present *Purāṇas*.

IV. CONCLUSION

This paper finds that *t* is rectilinear. The suggestion that *t* is a range of extent to

d seems to be reasonable and feasible. For further research it is recommended that *t* can be fully interpreted if some acceptable evidence or thought is put forward to support this suggestion.

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INDICATION AND ABBREVIATIONS

‹…›	contains paraphrase supplied by the present author to achieve fullness.
Fig.	Figure
Skt.	Sanskrit

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